



National Aeronautics and Space Administration
Jet Propulsion Laboratory
California Institute of Technology



EUROPA

CLIPPER

Europa Clipper Status Update

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Topics



- Project PDR and Path Forward
- 2023 Launch Opportunity & Potential New Trajectory
- Magnetometer and Instrument Cost Triggers



Project PDR



- Project Preliminary Design Review (PDR) conducted August 2018
- Significant issues identified by SRB:
 - Completion of the accommodation of the REASON antennas with the Solar Array
 - Concerns over the “self-compatibility” issues (contamination control, EMI/EMC, Planetary Protection, Surface Charging)
 - Workforce availability
 - Overall mission cost/schedule (related to issues sited above)
- DPMC at HQ on October 29, 2018
 - Project recommended, SMD concurred, slipping launch readiness date to 2023 (driven by workforce shortfalls, SI&T timeline and solar array schedule)
- Delta PDR scheduled for June 18-20, 2019



Progress Since PDR



- Planetary Protection Workshop
 - Confirmed Project statistical model for determining probability of viable spore reaching Europa ocean
 - Established parameters/requirements impacting implementation, examples include:
 - Minimum radiation dose for assuring sterility (2.5MRad)
 - Period of biological exploration (1,000 years)
 - 3-log reduction acceptable for bio-reduction processing
 - Required laboratory cleanliness (ISO-8 vs. ISO-7)
 - Project now meets level-1 requirement of $< 10^{-4}$ probability of a viable spore reaching Europa ocean
- Solar Array PDR/ Δ -PDR & Integrated Wing Review (IWR)
 - After multiple iterations on requirements for solar array and updates to radar modeling, design exists that allows progression to implementation for REASON
- Project re-plan for 2023 launch
- On plan for Delta-PDR and confirmation summer of 2019



Clipper Mission Overview



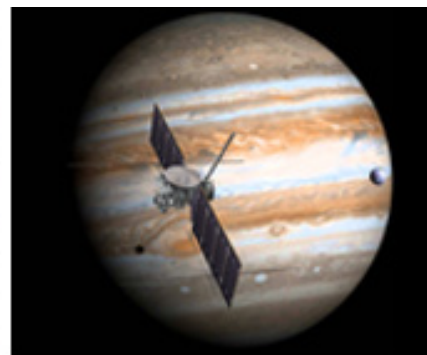
Earliest Launch

*Period: 7/4/23 – 7/24/23 (SLS)
*Period: 5/24/23 – 6/13/23 (EELV)
***Period: 11/12/23 – 11/30/23 (Δv -EGA)**



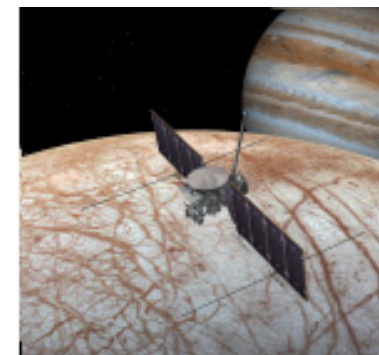
Cruise:

2.4 Years (SLS)
6.6 Years (EELV)
5.9 Years (Δv -EGA)



Jupiter Orbit Insertion

December 2025 (SLS)
January 2030 (EELV)
September 2029 (Δv -EGA)



Jovian System Operations

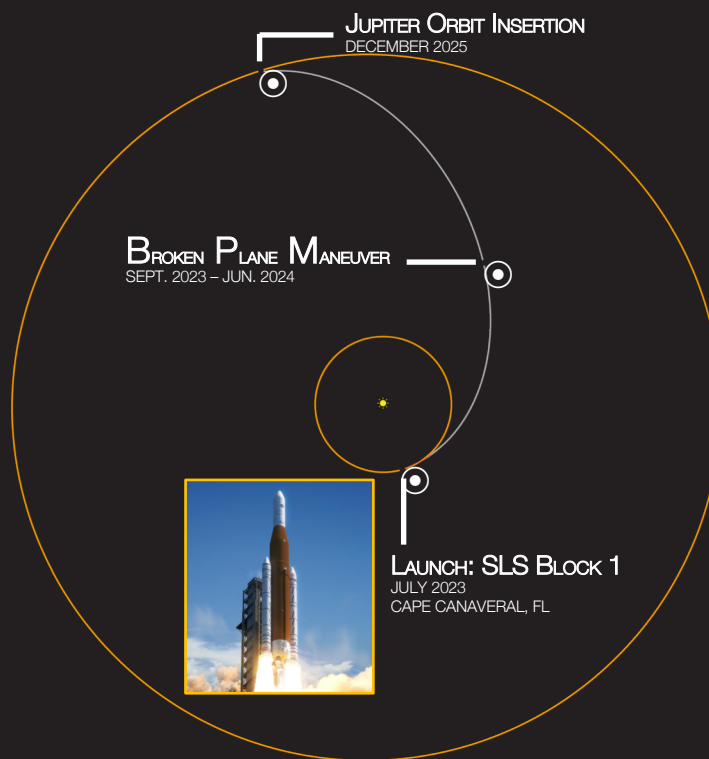
Transition to Europa Science: ~12 months
Prime Europa Flyby Campaign: ~36 months

- **Project Category 1**
 - LCC > \$1B
- **Mission Risk Class A (With tailoring)**
- **NPR 7120.5E Compliant (No waivers)**
- **S/C design compatible with both SLS and EELV**

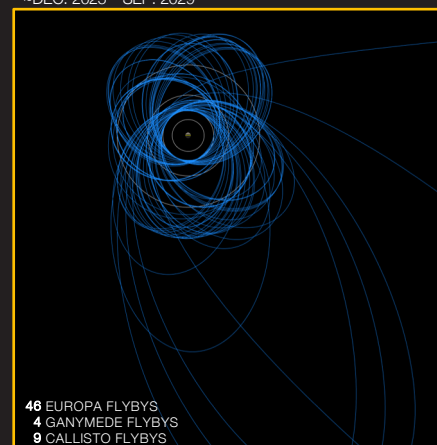
Direct-to-Jupiter Trajectory

NASA Space Launch System (SLS) Launch Vehicle

- 21+ day launch period opens July 2023
- 2.4 year transit time to Jupiter
- Jupiter System arrival in December 2025



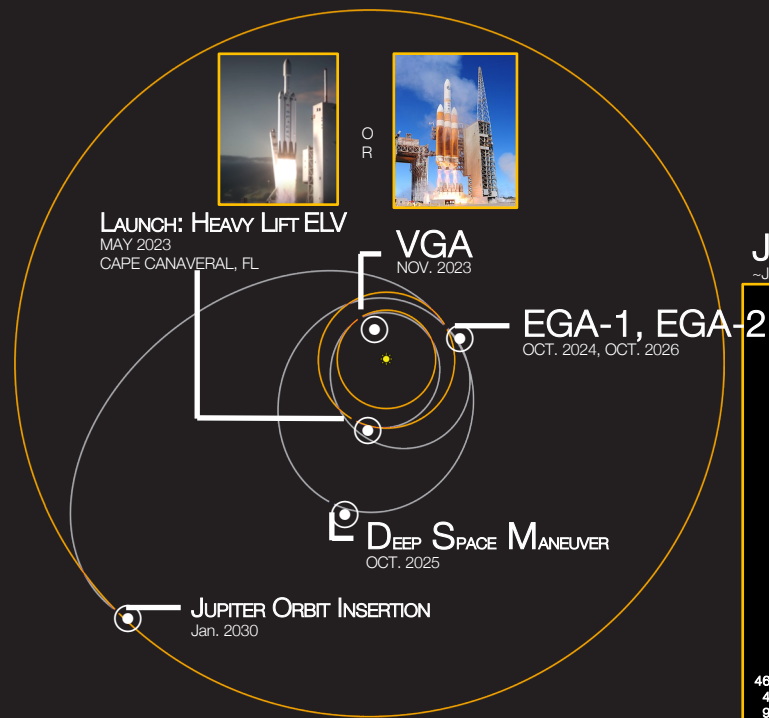
JUPITER ORBITAL TOUR
~DEC. 2025 – SEP. 2029



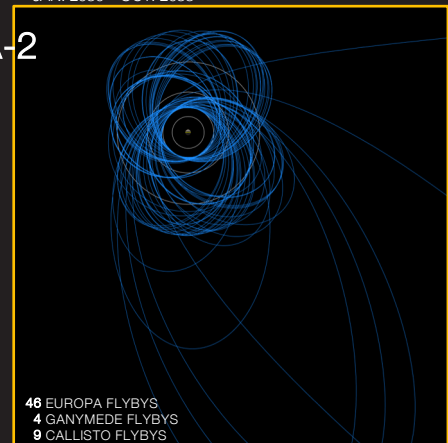
Venus-Earth-Earth Gravity Assist (VEEGA) Trajectory

Commercial Heavy Lift Expendable Launch Vehicle – Delta-IV Heavy / Falcon Heavy

- 21+ day launch period opens May 2023
- 6.6 year transit time to Jupiter
- Jupiter System arrival in January 2030



JUPITER ORBITAL TOUR
~JAN. 2030 – OCT. 2033



48 EUROPA FLYBYS
4 GANYMEDE FLYBYS
9 CALLISTO FLYBYS

ΔV Earth Gravity Assist ($\Delta VEGA$) 3-Minus*

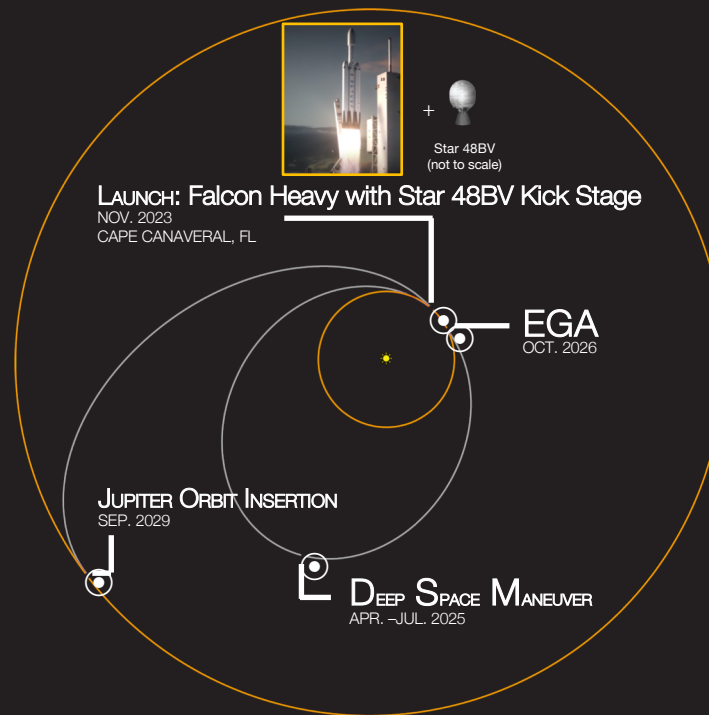
Trajectory

Commercial Heavy Lift Expendable Launch Vehicle – Falcon Heavy with Star 48BV Kick Stage

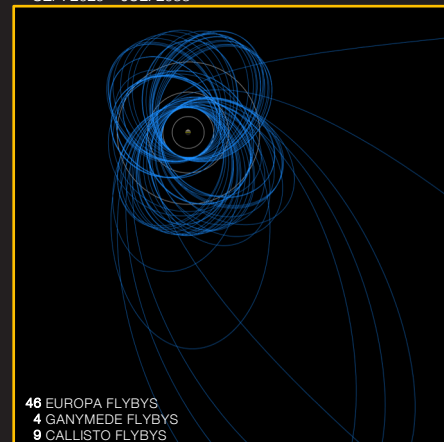
- 20 day launch period opens November 2023
- 5.9 year transit time to Jupiter
- Jupiter System arrival in September 2029

- **Min sun distance → 0.98 AU**
- **2024 Opportunity exists**

* "3-minus": The three indicated the spacecraft gets injected into roughly a 3:1 resonant transfer with the Earth, the minus indicates the EGA occurs before perihelion.



JUPITER ORBITAL TOUR
~SEP. 2029 – JUL. 2033





Magnetometer Implementation Change

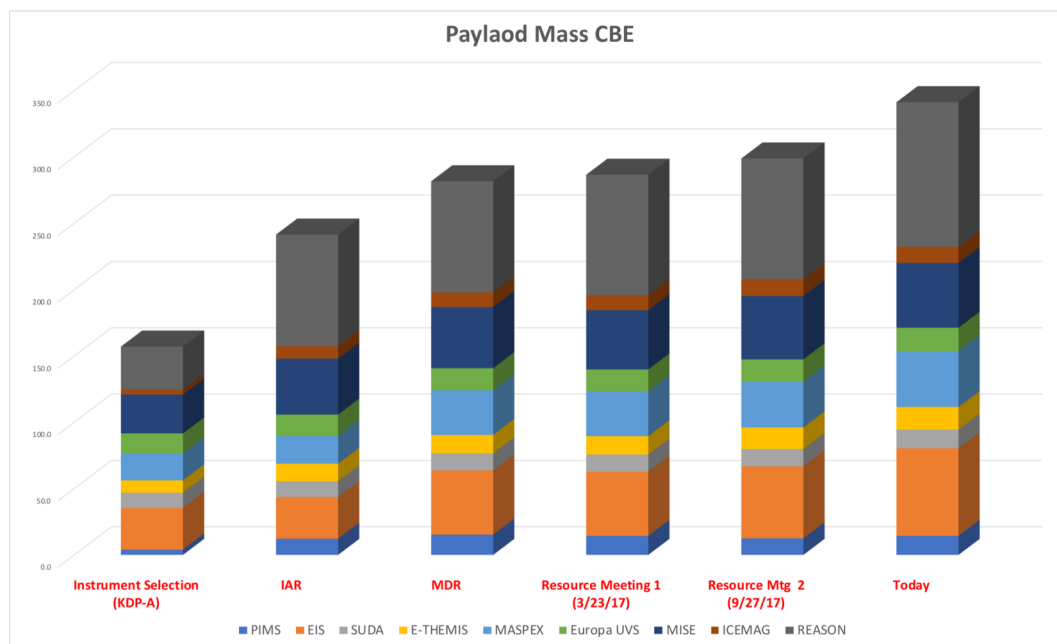


- NASA has decided to terminate the ICEMAG investigation
 - Requested project to recommend path forward for a 4-fluxgate sensor magnetometer facility instrument mounted on existing Europa Clipper five meter boom
- Project recommendation, concurred by Planetary Science Division:
 - Establishing contract extension with UCLA to provide four fluxgates for flight
 - Creating one delivery team, under a single Product Delivery Manager (PDM) to provide integrated and calibrated system consisting of the four flux-gates, electronics, software & magnetometer boom
- Will be proceeding and planning for an integrated CDR in late fall 2019



Payload CBE Mass

From March 8, 2018 Payload Resource Meeting



Milestone	PIMS	EIS	SUDA	E-THEMIS	MASPEX	Europa UVS	MISE	ICEMAG	REASON	Total
Instrument Selection (KDP-A)	4.0	31.4	11.4	9.4	20.2	15.1	29.3	3.9	32.3	157.0
IAR	12.2	31.4	11.8	13.3	21.0	16.0	42.3	9.4	84.0	241.4
MDR	15.3	48.3	13.0	13.9	33.6	16.8	46.0	11.0	83.7	281.6
Resource Meeting 1 (3/23/17)	14.3	48.3	13.0	13.9	33.6	16.8	44.7	11.2	90.8	286.5
Resource Mtg 2 (9/27/17)	12.5	54.3	13.0	16.3	34.6	16.8	47.7	12.6	91.0	298.7
Today	14.4	66.0	14.0	17.0	42.1	17.7	48.7	12.3	109.0	341.3



Background

From July 2017 SMD Meeting



- Due to unexpectedly large instrument cost growth (52%) in Phase A, KDP-B Action from APMC
 - *"Prepare a de-scope plan for Europa Clipper. Due by end of FY'17"*
- As we are currently still within the cost range from both KDP-A & KDP-B, PSD direction to the Project
 - Develop a process by which we can monitor cost growth of each instrument and execute de-scopes (in part or in total) to maintain cost control
- Progress to date
 - Development of Cost 'Triggers' for each instrument and a monitoring/action plan
 - Development of tool (P-STAF) to analyze each instrument's contribution to required measurements and the ability for 'what if' scenarios
 - PI generated options for de-scopes on their own instruments
 - Other cost saving de-scopes have been identified
- Need to discuss any additional requirements and plan to close APMC action by end of FY 17



Instrument Cost Trigger

From July 2017 SMD Meeting



- a) The Project has assigned each Instrument a cost number (Phases A-D), deemed the “Cost Trigger” to determine when action needs to be taken to assure that the instrument maintains cost control.
 - Scope growth imposed on instruments from other areas within the Project as determined by the PM will raise the instruments “Cost Trigger”.
 - Any approved lien that falls under this category will increase the trigger amount by the dollar value of the lien.
- b) If the Project has determined that an instruments Cost Trigger will be reached the individual instrument (PI/IM) will evaluate and implement de-scope actions that can be taken to reduce cost without impacting level-1 requirements.
- c) If no action can be taken to reduce the instruments A-D cost below the Cost Trigger without impacting level-1 science requirements as determined by the Project Scientist, then the Project Manager will assess the current budgetary situation and determine if the instruments Cost Trigger should be raised by encumbering Project UFE.
- d) If the answer to step c above is no, or the PI does not take action as described in step b above, a mandatory discussion on instrument de-scope(s) / performance reduction will be conducted.
 - Mandatory Participants: Principle Investigator, Project Manager, Project Scientist, Program Executive, Program Scientist, Mission Manager, Payload Manager and Project Business Manager
 - The outcome of this meeting shall be either a path to an instrument de-scope(s), or an action at HQ to schedule a Directorate level PMC to either request use of HQ held UFE or a modification to the Level 1 requirements accepting reduced performance.



Determining Initial Trigger Values

From July 2017 SMD Meeting



- Current best estimate at MDR less anticipated payload reductions/opportunities from September 2016 HQ meeting
 - These numbers include either ROMs or bottoms up estimates from Phases C/D
 - *Plus 20% of expected obligations to go* from end of Fiscal February, 2017
 - Plus any unrealized cost savings from the reductions/opportunities identified at the September 2016 HQ meeting plus 20%
 - If an instrument saves more than expected from said reduction, they have more than 20% above cost to go to the cost trigger
- All Initial Trigger Values were discussed with, and accepted by the PIs



Monitoring

From July 2017 SMD Meeting



- Data from Monthly instrument reviews used to update 'the value of the cost headroom as well as of a percentage obligations to go' on a monthly basis
- Presented to PE and MM monthly
- Any changes discussed with PI monthly



Monthly Cadence



- MMR Week – 1 →
 - Payload MMRs - Each instrument reviews technical, schedule and cost status, including requested liens and threats (or possible PI initiated/recommended de-scopes)

- MMR Week →
 - Tuesday - Payload and business office reviews each instruments current status, including evaluation of liens and threats (PM adjust)
 - Wednesday – Monthly report generated
 - Thursday AM – Europa Clipper MMR
 - Thursday PM – Management review with Mission Manager and Program Executive
 - *If actions to be taken, path forward discussed here*

- MMR Week + 1 →
 - Payload office meetings with each instrument team reviews their chart (including rationale for PM adjust)



Reminder

From March 8, 2018 Payload Resource Meeting



- Cost triggers were established as response to a direction from PSD/SMD to Project to establish a plan to monitor and control costs of the payloads
 - This was in lieu of de-scoping part or all of one of the investigations
- Cost triggers were set after an aggregate increase of cost (CBE) of 52%
- Assumed 30% cost growth above MDR CBE for phases A-D, and Triggers were set to 20% to allow time to resolve the concern of hitting the trigger.
- 30% cost growth is equivalent to 95% cost growth from the proposed A-D CBE (after compounding is considered)



Process

From March 8. 2018 Payload Resource Meeting



- The process, by necessity, has level of subjectivity
- However:
 - The process is transparent
 - *Monthly, the week after the numbers are generated, they are sent to each of you*
 - The process has an appeal path
 - *Even in the worst case, when no agreement is reached, the issue is resolved at the HQ level*



Example Trigger Table (Data in table example only)

			Instrument-A	
Instrument CBE at MDR	(A)	→	Initial Adjusted CBE	\$25,000
120% of Initial CBE	(B)	→	Initial Trigger Point	\$30,000
Approved trough Lien meeting	(C)	→	Approved Instrument Liens	\$500
Small changes outside lien process	(D)	→	Admin Change Liens	\$0
Liens proposed not processed	(E)	→	Current Instrument Liens	\$1,000
Identified threats from your MMR	(F)	→	Current Instrument Threats	\$500
			Last Months PM Adjustment	\$100
Cost threats identified outside MMR	(G)	→	**This Months PM Adjustment	\$200
Impact increased CBE and trigger	(H)	→	External Impact to Instrument	\$500
P/L impact to (P/L, S/C, etc.)	(I)	→	Instrument Impact to External	\$0
A + C + D + E + F + G + H	(J)	→	PM Current Best Estimate	\$27,700
Portion of H without 20% headroom	(K)	→	External Impact to Instrument	\$100
Portion of H with 20% headroom	(L)	→	External Impact to Instrument (with 20% margin)	\$400
B + K + (L x 1.2) - I	(M)	→	Adjusted Trigger Point	\$30,580
M - J	(N)	→	Headroom To Trigger	\$2,880
Obligations to completion of Phase D	(O)	→	Obs To Go	\$15,000
N / O		→	% Obs To Go	19.20%

Current Headroom Trend Chart



Instrument Trigger Point - Trend Chart

